# EVALUATING LOCATION BASED PRIVACY IN WIRELESS NETWORKS

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**Abstract:** Research into the use of Location Based Services (LBS) that can pinpoint the exact location of users using wireless networks is the fastest growing area in Information Technology (IT) today. This is because of the need to transform the radio waves which act as a wireless networks data's transmission medium into a private location. Contemporary research on LBS suggests that indoor location can be difficult as the geo positional satellites (GPS) cannot give an accurate positional computation due to insulation provided by physical barriers like the walls and furniture of a house. Previous research however suggests a way around this by making use of wireless fidelity (Wi-Fi) cards signal strength but acknowledges limitations on the range which doesn't exceed 50 meters. Other researchers have suggested that using LBS technology would allow hackers to track the user's movement over time and so proposed that the user identity be kept secret by disposing the identifiers. Against this backdrop, some researchers have championed the call for a framework in LBS privacy in order to curtail the security risks that come with using wireless networks and suggested using a transaction-based wireless communication system in which transactions were unlinkable. This would in effect camouflage the movement of users as their location would not be able to be tracked. This paper aims to review contemporary issues on location based privacy in wireless technology and proposes a model for optimising LBS privacy and describes the initial stages of a research project aimed at filling the research void through the application of a hybrid research methodology

## 1. Introduction:

With the continuous growth in change from wired to wireless technology devices been used globally, the need to pinpoint a wireless device users exact location has become a necessary security feature of today's mobile technology. This is because today's wireless technology uses various location sensing technologies that experience limitations on accuracy and coverage. Most recent research suggests that the ultra-wideband radio technology can be used to pinpoint a user's exact location within an indoor environment, however this technology is still being experimented with; this was the main drawback of the global positioning system (GPS) which has been the main location sensing technology for decades (Jiang, B. and Yao, X. 2006). It is against this backdrop that a location based service framework has been suggested by leading researchers within the field in order to mitigate against the limitations of using location based services (LBS) without provisions for information security as required by ISO27001. In order to understand the contemporary issues affecting location based services then we must first define it; Koeppel (2000) defines LBS as 'an extension of Geographic Information System (GIS) capabilities by an application'. Shiode et al (2004) define LBS as 'a Geographical Information System (GIS) used across a mobile ICT network'. In support of these definitions the complexity of applications that extend Location Based

Services have been described as 'often having unique requirements for data collection, integration, and accuracy analysis' Jiang, B. and Yao, X. (2006). Other researchers have described LBS as the delivery of information and services tailored to the current or some projected location and context of the user; (Brimicombe & Li, 2006). It was due to these unique requirements and limitations that researchers began the development of a framework in order to understand and address the security risks caused by using location based service technology (Minch, R.P 2004).

## 2. Related work:

Some of the security risks of location based privacy that were identified by; Minch, R.P (2004) included the following issues. "**Issue 1:** Should users of location-enabled devices be informed when location tracking is in use? Should they be permitted to turn it off? Should an opt-in or opt-out approach be used? What factors will determine these answers? **Issue 2**: Should users of location-aware devices be permitted to control the storage of location information? **Issue 3**: Should location information as stored be personally identifiable, or should the user have options to preserve degrees of anonymity? **Issue 4**: What legal protection should a person's historical location information have against unreasonable search and seizure? **Issue 5**: Should there be other controls governing aspects of stored location information, such as verifying accuracy, specifying retention periods, requiring particular levels of security, etc.? **Issue 6**: Does the use of location information by a second party such as a communications carrier, even if not disclosed to third parties, create the potential for unfair advantage for those carriers or abusive use of the information by those carriers? **Issue 7**: To what extent should users of location enabled services be allowed to choose their own level of identifiability/anonymity? **Issue 8**: What level of disclosure control should be dictated by government regulation? By the affected individual customers, users, etc.? By other parties? **Issue 9**: What governmental legislation and regulation is appropriate to assure citizens' rights of privacy in an era of location-aware mobile devices? **Issue 10**: Will non-governmental, voluntary standards be sufficiently strong and sufficiently accepted by industry and consumers to be effective? **Issue 11**: Will industry/trade group standards be sufficiently strong and sufficiently accepted by industry and consumers to be effective? **Issue 12**: Will advocacy/public interest groups be capable of sufficiently monitoring the burgeoning location-aware industries, and sufficiently effective in protecting the public's interests? **Issue 13**: Will consumers demand, and will suppliers provide, privacy-related capabilities, features, and policies with their products and services that are sufficiently strong and accepted to be effective?"

The issues stated above relate to the user & Location Based Service (LBS) interaction, and provided little consideration for the technological elements of the interaction; Golledge & Stimson, (1997); Kitchin & Blades, (2002). 'In LBS research, such a technological element is present as an information source delivered through a mobile device' **[3]** and is key to providing privacy and security for data transactions; As a result of this gap in LBS technology research paper Li, C. (2006) proposed a model for understanding the technological elements in LBS

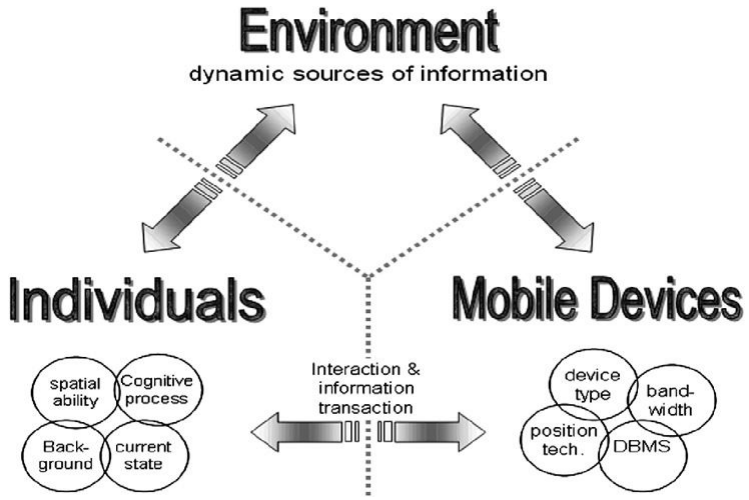


Fig. 2. A conceptual model for understanding LBS technological interactions; (Li, C. 2006)

The model uses a questionnaire to gain an understanding of each LBS user's spatial ability. The wireless device usage was recorded along with the track taken by individuals in the experiment. However the study acknowledges its limitations as being the movement of the wireless device which is directed by a joystick rather than the actual movement of an individual; this is considered a limitation in replicating the real world. However responses to the post-experiment questionnaire showed that the way finding behaviour in VR did indeed accord with their usual real world behaviour. This paper proposes the use of the security issues faced by large and medium registered companies in the UK collected by a designed questionnaire and developed into a security risk model. This paper also proposes the use of the actual movement of wireless devices by individuals in a controlled environment that can be tracked and monitored and whose data can be collected and fed into the security risk model in order to understand the current, emerging and real threats faced by the companies in the UK. Finally this paper proposes the use of this risk model to develop a trust model that can be used to mitigate the risks to privacy in Location Based Services (LBS). This approach is used by (Wealands, K; et al 2007) in a research article on understanding the needs of LBS users and for profiling their behaviours into groups

## 3. Model Analysis:

The model in this paper is similar to the model used by; Jokela et al 2003 but different in that it focuses on the technological elements of LBS transactions.

## 4. Research method and methodology:

The methods used to collect the data in this research paper shall be a combination of interviews and online questionnaires based on the LBS technological transaction Model and the results computed by a statistical package (SPSS) in order to analyse the findings. In order that the data can be analysed the likert questionnaire methodology shall be used in order for the ata to be modelled in an appropriate manner.

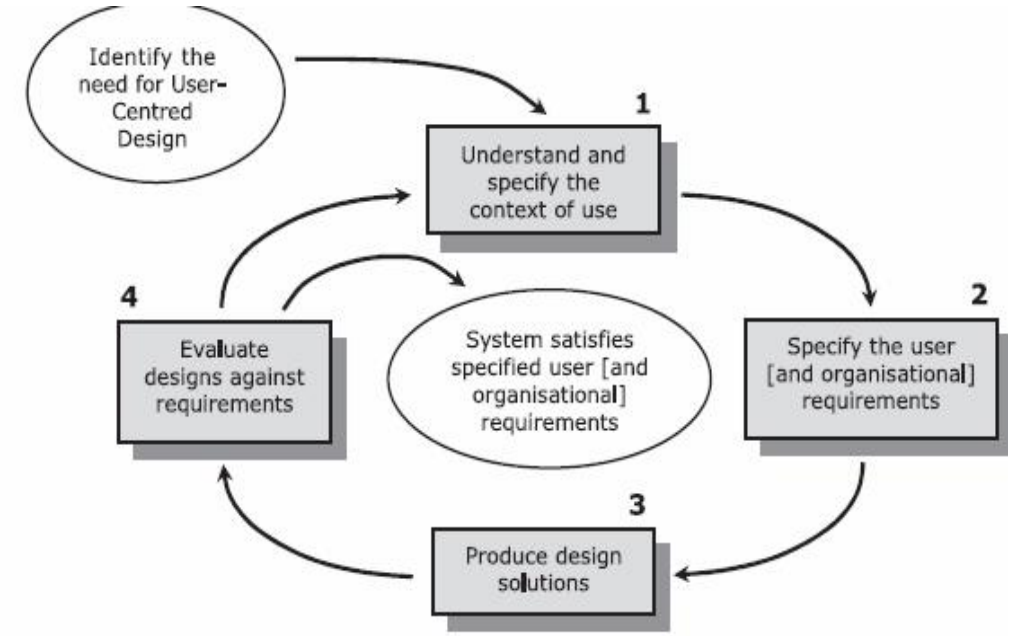


**Figure 1** The main activities of User Centred Design (Jokela et al. 2003)

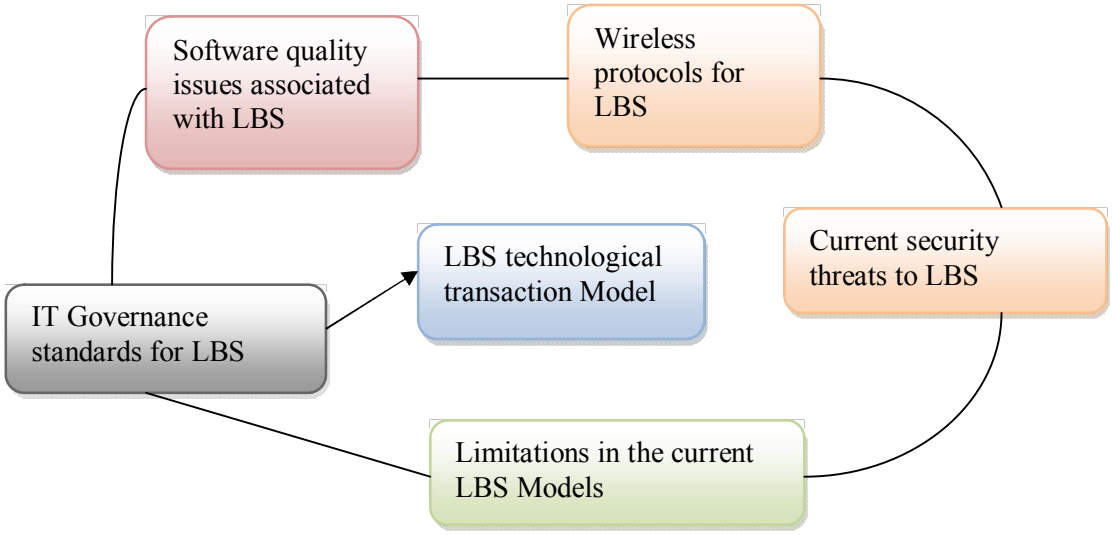


Fig. 3. LBS Technological Transaction Model (TTM)

| Domains | Building Blocks | | Selected Questions |
|---|---|---|---|
| Software quality issues associated with (wireless location based systems) | Functional | Security | a) How important is the quality of software used to develop and implement (wireless location based systems)<br>b) How important is the standardisation of the quality of software used by your organisation in accordance with internationally recognised standards e.g. British Standards / International Standards Organisation<br>c) How important is the efficiency and performance of software when developing, acquiring or implementing (wireless location based systems) within your organisation<br>d) How important are the End user experience of software for (wireless location based systems) used in your organisation |
| Limitations in current (wireless location based systems) models | Functional | Security | a) How important are the shortcomings in the development or implementation of (wireless location based systems) taken by your organisation<br>b) How important is research when planning the annual budget and strategy in your organisation<br>c) How important are emerging technologies taken in your organisation with regards to (wireless location based systems)<br>d) How important is the interference to radio signals from other wireless appliances in the functionality of the (wireless location based systems) |
| Ethical issues in (wireless location based systems) | Strategic | Management | a) How important is surveillance an issue for you when using wireless location technology that can monitor your activities at work and or at home<br>b) How important does your organisation consider ethical issues regarding wireless location technology<br>c) How important is the loss of your identity through tracking to monitoring personnel when using the |

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|---|---|---|---|
| | | | wireless location technology<br>d) How important is the consideration given to your health taken by your organisation due to your exposure when using (wireless location based systems) e.g. through training and proper use of equipment |
| Current security threats to wireless networks | Functional | Security | a) How important are wireless technological threats in developing or implementing (wireless location based systems) in your organisation<br>b) How important is the update or upgrade of the (wireless location based systems) security due to evolving wireless network security threats<br>c) How important is the leakage of radio waves when developing (wireless based location systems)<br>d) How important are the non controllable aspects of the (wireless based location systems) with regards to strengthening security |
| IT governance standards for (wireless location based systems) | Regulatory | Governance | a) How important are the External regulatory laws e.g. Information Technology Audit rules when developing (wireless location based systems)<br>b) How important are the Information Technology regulatory bodies an impact on the operations of your organisation<br>c) How important is the membership of the Information Technology bodies to your organisation<br>d) How important is the compliance of the laws and regulations of these bodies to your organisation |
| Wireless protocols for (wireless location based systems) | Functional | Security | a) How important are the use of international protocols, in the development, acquisition or implementation of wireless location systems in your organisation<br>b) How important is the adoption of new international protocols taken when developing and implementing a new (wireless location based systems) in your organisation<br>c) How important is the dedication of |

| | | | |
|---|---|---|---|
| | | | personnel, time and money (resources) to the maintenance of these protocols to your organisation<br>d) How important are the implications of not adhering to current international protocols to your organisation |

Table 1: LBS technological transaction model Questionnaire

| **Domain Question** | **Majority percentage response to domain** |
|---|---|
| Software quality issues associated with (wireless location based systems) | Software quality issues were considered very important by most companies contacted |
| Limitations in current (wireless location based systems) models | LBS Research was not considered an important area in annual company budgets as its development and maintenance was outsourced to 3rd parties |
| Ethical issues in (wireless location based systems) | Ethical issues concerning LBS was not considered important by the responding companies |
| Current security threats to wireless networks | Security threats to LBS was considered very important by the responding companies |
| IT governance standards for (wireless location based systems) | External regulation was very important for all companies contacted |
| Wireless protocols for (wireless location based systems) | Adhering to LBS protocols was very important for all responding companies |

Table 2: LBS technological transaction model questionnaire results

The validity and rigour of the research approach is concerned with consistency in the development of the themes that are considered unique to the LBS technological transactions under study. No effort is being made to ensure the reliability of the statistical results, but the focus has been on using recognised Information Technological Governance standards in ensuring that the privacy of the LBS adheres to known and current international standards e.g. ISO27001 and other protocols.

The methodology which combines qualitative and quantitative approaches is in

accordance with triangulation methodologies and represents that multiple use and interpretation of methods in order to justify the identified themes.

## 5. Results:

Overall a number of design implications were posed by the user assessment which was classed into Executive, Functional and Operational users. However, the questionnaire provided a useful insight to the operations of each responding organisation and the culture and or strategy used by the organisation in dealing with the privacy issues of LBS. Some of the findings include but are not limited to the following. One of the results from the Ethical domain agree with some of the findings in the Communications of the ACM Journal (Junglas, I.A & Watson, R.T; 2008), which suggests that users are less concerned with the ethics of LBS tracking but more with the task it can perform.

## 6. Conclusion:

This paper has been used to show the early findings of the privacy profile for developing a technological transaction model in location based services through a technological requirements approach. The next phase once all the results have been returned will be to take all the returned results and use them in developing a security strategy model. These will then be evaluated by way of an experiment that uses location based services in the security strategy model

## 7. Future Research:

There are many easy answers to the privacy questions raised by location-aware devices but no single control is likely to assure privacy. This is because not all the uses of location information can be pre-empted, and not all its risks can be prevented. Further research will be needed in many areas, these include but are not limited to: the theories of location-based information and location-based privacy and the technical capabilities of location based services technology; however it is expected that by pre-empting the problems in advance as possible, then users will be able to get the best out of LBS technology.

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